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ABSTRACT

This Quinmester elective course for grades 10, 11, and 12, investigates the impact of science on society and the effects of technology on the values, institutions, behavior and health of American society. The course is suited for independent study by those planning a career in the sciences and others. Students are led to examine the role of science in society and to draw conclusions about the obligations of a scientist to his profession, his country, and mankind. Following a statement of rationale, a list of course goals, a course outline, and a list of activities, a focus is given to each goal with coordinated objectives and learning activities. Appendices include a poem, a statement on technology assessment, and a court of appeals opinion (unreproducible). A list of materials contains basic texts, alternate student and class materials, supplemental information for students and teachers, and periodical and juournal articles. (KSM)

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AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

SD 006 830

Social Studies

Science and Society
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DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1971

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SOCIAL STUDIES

SCIENCE

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by

MARGARET E. LA ROE

for the

Division of Instruction
Dade County Public Schools
Miami, Florida
1972

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INTRODUCTION

This course of study was written as part of a total effort to revise curriculum to fit the quinmester administrative organization of schools. The materials and information in this guide are meant to be neither all-inclusive nor prescriptive; but rather, an aide to teachers as they plan instructional programs, taking into account student needs and characteristics, available resources, and other factors.

The major intent of this publication is to provide a broad framework of goals and objectives, content, teaching strategies, class activities, and materials all related to a described course of study. Teachers may then accept the model framework in total or draw ideas from it to incorporate into their lessons.

The guide is divided into 1) a broad goals section, 2) a content outline, 3) objectives and learning activities, and 4) materials. The first section provides descriptive and goal-oriented information for the teacher; "indicators of success" refers to suggested prerequisite or corequisite experiences. The content outline illustrates, in general terms, the scope and major subdivisions of the course. The objectives and learning activities section, hopefully, provides a total picture of the concept or main idea and specific behavioral objectives for a set of given learning activities. The materials section of the guide lists resources in four categories: essential textual or other material; alternate classroom materials to use in place of or in addition to the aforementioned; supplementary teacher resources; and supplementary student resources. The appendix may include other material appropriate for a specific course: e.g. pretests, readings, vocabulary, etc.

Anyone having recommendations relating to this publication is urged to write them down and send to, Social Studies, Room 306 Lindsey Hopkins.

James A. Fleming
Social Studies Consultant

COURSE DESCRIPTION: INVESTIGATES THE IMPACT OF SCIENCE ON SOCIETY. THE EFFECTS OF TECHNOLOGY ON THE VALUES, INSTITUTIONS, BEHAVIOR AND HEALTH OF AMERICAN SOCIETY WILL BE INVESTIGATED.

GRADE LEVEL: 10-12

COURSE STATUS: Elective

INDICATORS OF SUCCESS: None

COURSE RATIONALE: Modern man is facing many crucial decisions closely related to science: pollution, space exploration, uses of the sea, weapons, drugs, and human organ transplants. In the future he will have to cope with decision-making about genetic controls, bio-chemical control of man's thought and behavior, possible development of doomsday viruses and the test-tube creation of life.

All students should examine for themselves the possibilities of science as savior or destroyer. They should recognize the role of science in the society in which they live, and draw conclusions about the obligations, sometimes conflicting, of a scientist to his profession, his country, and mankind.

This course is also suited for independent study for students planning a career in the sciences.

COURSE GOALS:

1. THE STUDENT WILL DESCRIBE THE ROLE OF SCIENCE AND SCIENTISTS IN THE DEVELOPMENT OF WESTERN SOCIETY.

2. THE STUDENT WILL GENERALIZE ABOUT THE RELATIONSHIP BETWEEN SCIENCE AND OTHER AREAS OF HUMAN LIFE.

3. THE STUDENT WILL ASSESS THE DEGREE TO WHICH SCIENTIFIC RESEARCH IS DEPENDENT UPON PUBLIC ATTITUDES AND VALUES.

4. THE STUDENT WILL ANALYZE THE EXTENT TO WHICH SCIENTISTS SHOULD: A) CONCERN THEMSELVES WITH THE CONSEQUENCES OF THEIR WORK: AND B) BE ABLE TO INFLUENCE HOW THEIR WORK IS APPLIED BY SOCIETY.

5. THE STUDENT WILL SPECULATE AS TO THE FUTURE ROLE OF SCIENCE AND TECHNOLOGY IN THE WORLD.

COURSE OUTLINE:

I. History of Science

A. Science and the development of western society

B. Effects of the scientific revolution

C. Historical trends in scientific advances

II. Science and Technology

A. Distinguishing between science and technology

B. Distinguishing between basic science and applied science

C. Relationship among science, technology, and applied science

D. Social effects of science and technology

1. Beneficial and harmful effects

a. Environmental
b. Social
c. Economic

2. Effects on important modern trends

a. Urbanization
b. Population
c. Leisure Time
d. Pollution
e. Others

E. The relationship of science and:

1. War
2. Religion
3. Agriculture
4. Art
5. Literature
6. Education
7. Privacy
8. Human Mortality
9. Transportation
10. Values
11. Politics
12. Experimentation with human subjects
13. The family
14. Medicine
15. Law

III. The Scientist and the Public

A. How society affects science

B. Public opinion toward science and scientists

IV. Social Responsibilities of Scientists

A. Social activism by scientists -- pros and cons

B. The proper role of the scientist as:

1. Educator
2. Decision-maker
3. Interest group
4. Advisor
5. Dissenter

COURSE OUTLINE: (cont.)

V. The Future of Science

A. The impact of science on society

B. Changing attitudes toward science by the public

INTRODUCTORY AND LONG-RANGE ACTIVITIES:

1. An opening discussion might center on several crucial questions which will be examined throughout the course. They might be presented on a transparency, one at a time; students asked to interpret each question, copy it in their notes, and exchange ideas casually, about their feelings on the questions.

   a. Is science a destroyer or a savior?
   b. Should all students be required to take science courses?
   c. Should a scientist participate in work which is aimed at destructive ends?
   d. Should scientists be able to influence how their work is used?
   e. Is a scientist's first loyalty to country or to mankind?
   f. Is scientific research subject to the whims of the public and government?
   g. Should scientists be required to study other fields, such as humanities?
   h. Are the men who developed the atomic bomb responsible for its destructive results?
   i. Can science solve society's problems?
   j. What is the relationship between science and society today?
   k. How will science affect society in the future?

2. Read and discuss the introduction to the pamphlet, Science and Public Policy, page 5.

3. Many long range projects are possible. One or two days a week might be set aside throughout the course for individual work on some of the following assignments:

   a. Each student might be required to read a book of current interest on the general topic of the course. Many are available in paperback, and several copies of each could be placed in the classroom. (See Materials Section, Supplemental Student Resources)

   b. Require each student to read a certain number of relevant periodical articles. (See Materials Section, Periodicals)

      The teacher might obtain reprints or make copies of pertinent articles and keep them in a vertical file for student use in class.

   c. Have each student research and present a written and/or oral report on an important issue involving the relationship of science to society. As an ongoing part of this course the class should follow significant current issues involving science and society in newspapers and magazines.

GOAL 1: THE STUDENT WILL DESCRIBE THE ROLE OF SCIENCE AND SCIENTISTS IN THE DEVELOPMENT OF WESTERN SOCIETY.

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
SCIENCE AND WESTERN SOCIETY	The student will describe the role of science and scientists in the development of western society.	1. Utilize all or parts of the unit, "The Birth of Modern Science" (Chapter 7) in the state adopted textbook, The Shaping of Western Society. Using inquiry, this unit traces the transformation of medieval thought into the scientific revolution. 2. Read and discuss "The Trial of Galileo" in the pamphlet, (P. 7-12) Science and Public Policy. This pamphlet is highly recommended. "The Trial of Galileo" might be reserved for use when dealing with the issues of science and public attitudes. You also might show the film, Galileo: the Challenge of Reason, and discuss its contents. 3. Have a group of students research and prepare a poster or bulletin board displaying a "Timeline of Scientific Advances." 4. Have students interpret and discuss this quote: "The greatest invention of the nineteenth century was the invention of invention. A new method entered into life. In order to understand our epoch, we can neglect all the details of change, such as railways, telegraphs, radios, spinning machines, synthetic dyes. We must concentrate on the method itself; that is the real novelty which has broken up the foundations of the old civilisation. ...and man, who at times dreamt of himself as a little lower than the angels, has submitted to become the servant and minister of nature. It still remains to be seen whether the same actor can play both parts." (Alfred North Whitehead)

FOCUS	OBJECTIVE	LEARNING ACTIVITIES

4. (cont.)

   a. What is the author's hypothesis?
   b. What, in particular, is the author referring to when he says that the scientific method has broken down the old civilization? (religion)
   c. The author said this in the 1920's. Is his hypothesis still true in the 70's?
   d. What might Mr. Whitehead say about the popularity of ecology today? (part of the move toward becoming "the servant...of nature.")

5. Have each student write an essay on one of the following topics, showing its relationship to science and technology:

   The Reformation
   The Age of Exploration
   Agricultural Revolution
   Industrial Revolution
   Atomic Revolution
   The Renaissance

   Be sure that some students are working on each topic. In sharing the essays when concluded, have students who worked on a given topic get together and complete appropriate parts of a chart:

Topic	Approx. dates	Important Events, people	Scientific and Technological advances	Hypotheses (relation to science and technology)

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
		6. Have each student select the 10 inventions that he believes have most influenced man and western society. He should write a paragraph on each giving evidence for having chosen that particular invention. This may also be done in small groups and shared via oral reports. 7. Divide the years 1850-1950 into ten-year segments. Have small groups (about 3 each) research decades to make a list of significant scientific and technological advances for that period. From ensuing discussion, students should be able to: a. Categorize periods when science and technology have advanced most rapidly. b. Critically discuss the relationship between scientific and technological advances and war. c. Hypothesize that the pace of scientific and technological advances has steadily increased. d. Hypothesize that theoretical advances have occurred between wars and applied advances during war. (e.g. the theory of relativity and the development of atomic weapons) 8. Have individual students write reports or give oral reports on influential scientists of the 17th - 19th centuries. 9. Culminating questions for discussion or writing: a. How did the scientific revolution change the way men thought and what they believed? b. What conditions favor (have favored) advances in science and technology? c. How have each of these scientific fields contributed to mold western society as we know it today: astronomy, physics, mathematics, biology, chemistry?

GOAL 2: THE STUDENT WILL GENERALIZE ABOUT THE RELATIONSHIP BETWEEN SCIENCE AND OTHER AREAS OF HUMAN LIFE

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
SCIENCE & TECHNOLOGY	A. The student will distinguish between science and technology.	1. Have students look up definitions of science and technology. Write simple definitions on the board. 2. Give students a list of achievements from the past and identify whether they are examples of scientific or technological advances. Conquering of small pox, polio First heart transplant Genetic mechanism: DNA Increased agricultural yield Theory of evolution Interstate highway system Grand Coulee Dam First Atomic bomb George Washington Bridge Automobile Laser beam Moon landing Relativity As students discuss choices, they should explain how they divided the items in categories. From the discussion, students should be able to arrive at a generalization that technological advances are based on scientific discoveries and that progress in these areas today is usually a result of both. 3. Discussion: a. How are science and technology related? b. Is one more important than the other? c. Does one precede the other? d. What occupations involve science? technology? 4

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
		3. (cont.) e. Are any of the items on the list overlapping into both science and technology? f. How are basic science and applied science interrelated? g. Is there necessarily a continuum of basic science -- applied science -- technology?
SOCIAL EFFECTS OF SCIENCE & TECHNOLOGY	B. The student will gather information about the effects of science and technology on society.	1. Divide the class into several groups. Have each one take a past achievement in science/technology and fill in a chart as follows:

	Achievements	Beneficial Effects	Harmful Effects	Future Implications
e.g.	Harnessing of atomic energy			
	Landing on the moon			
	Invention of the printing press			
	Mass production			

(Other achievements may be used. Students should be able to generalize without using sources.)

2. Discuss the results of the group work. Stress the idea that there are economic, social and environmental

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	B. (cont.)	2. (cont.) effects of these and all significant developments in science and technology. For example, ask: a. What was the social cost of the development of mass production? Do other technological advances create these problems? (Loss of identity with product created, loss of pride in work, advent of large companies instead of small, etc.) b. How have science and technology contributed to the following trends in modern society? urbanization population growth increasing leisure time pollution c. Could the inventor of the printing press predict how his invention would affect society in the distant future? Do scientists today accurately predict the effects of their work? Is it possible to predict how current experiments with genetic make-up will affect future generations? 3. Have an interested student or group of students report on the effect of a sudden advent of technology in primitive societies (Indians, Australian Aborigines, etc.). Discuss: a. Why do some primitive societies resist the introduction of western ways? b. Do the most primitive societies have technology? 6

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	B. (cont.)	3. (cont.) c. When modern technology is introduced to these peoples why might it have harmful effects? (Social change lags behind technological change; Institutions and values conflict with new "machines;" Rising expectations.) d. Do some of the same harmful effects appear in our society? (Students might suggest the breakdown of family unit; increase in crime; lack of identity; breakdown of religion; loss of individuality.) 4. A very able student might read Kafka's story The Metamorphosis, and write an essay explaining Kafka's message about the effects of technology on society. (The main character, a factory worker, wakes up one morning a cockroach; as an insect he has lost his individuality, his identity as a human.) 5. Hand out (or have a student read aloud) copies of Lawrence Ferlinghetti's poem from A Coney Island of the Mind, #1. (See Appendix.) If a slide of a Goya war-time painting is available, display it while reading the first part aloud. Ask: What does Ferlinghetti think about our technological society? Students can locate and bring in other poems or literature which reflect effects of technological change.

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	C. (cont.)	3. The topics under #C-1 are at the heart of this quin. Students might be asked to select one or more topics and do research in periodicals and books leading to a written or oral report. 4. Have students try to identify 10 (or some number of) values that are most important to the American value system. This might be assigned as homework; on the following day assign groups to prepare an agreed upon list to present to the class. As the class attempts to reach a concensus list, discuss how science and technology have influenced American values. Suggested list of values: achievement and success work humanitarian efficiency and practicality progress material comfort equality freedom external conformity scientific rationality

GOAL 3: THE STUDENT WILL ASSESS THE DEGREE TO WHICH SCIENTIFIC RESEARCH IS DEPENDENT UPON PUBLIC ATTITUDES AND VALUES.

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
SCIENTIFIC DEPENDENCE ON THE PUBLIC	A. The student will examine cases to discover ways that science depends on the public.	1. Discuss general ways that society affects science. a. What conditions have favored scientific advances in the past? (Relate back to goal 1; compare the Renaissance social and value situation with that of the Middle Ages.) b. Is any one political system more favorable to science than others? Note that some dictatorships, e.g. U.S.S.R. today, encourage research that might even interfere with their beliefs - why? (Stalin period - Lysenko) c. How do scientists get the money needed to carry on research? (industry, government, private foundations, universities) d. What kinds of strings are attached, then, to scientific freedom? e. Why might it be more difficult to get funding for basic research than for applied research? (No practical economic, military, etc., benefits are predictable from basic research.) f. Who decides what kinds of scientific research will be carried on and emphasized in this country - scientists or others (politicians and businessmen ....)? (For evidence students can point to the emphasis on research which government and "society" have condoned, e.g. cancer research, electronics, etc. and a lack of support for more controversial projects.) g. Is science and technology dependent on public support in the U.S.? In the U.S.S.R.? (Consider the effect of Sputnik)

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	A. (cont.)	2. As a class select 5 or 6 important scientific or technological achievements in different times and locations. Divide the class into as many groups as there are topics. (Topics are suggested below.) Have each group determine for one topic? Whether the research was basic or applied? Where the financial backing came from? What were the motives of the financial supporters? Was there popular support? governmental support? Why was this particular project or research undertaken and not something else? What were the short-term and long-term results? Suggested topics: The Challenger Expedition, The Deep-Diving Submarine (Aluminaut), The First Satellites (effect of Sputnik), Man on the Moon, Lewis and Clark Expedition, first transcontinental railroad connection, IGY. 3. Make hypotheses based on the following facts, with regard to amount and type of scientific research support in the U.S. a. In 1969 65% of funds spent on basic and applied research and developmental technology in the U.S. were provided by federal agencies. b. In 1965 the science budget = 2.5% of the G.N.P. In 1969 the science budget = 2.0% of the G.N.P. c. The main supporters of basic science research in the U.S. are: Department of Defense Atomic Energy Commission National Institute of Health National Aeronautics and Space Administration (NASA)

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	A. (cont.)	3. (cont.) c. (cont.) The National Science Foundation provides less support than the above agencies. Possible hypotheses to be further tested: a. Popular support for science has declined. b. Main support for scientific basic research comes from agencies whose main concern is not science. c. The federal government exerts a great influence over the direction of scientific research in the U.S. 4. Have students formulate a questionnaire to determine student attitudes toward science. Questions revolving around current issues should yield some hypotheses about the attitudes of the public toward science. Use the Sociological Resources for the Social Studies booklet Science and Society, section 1, as a guide in making up a questionnaire. A sample questionnaire accompanies the unit. 5. Have an interested student make a report on the Scopes Trial. An account of this appears in the film, Clarence Darrow. 6. The example of Galileo in the AEP unit book, Science and Public Policy, demonstrates the ways that the value system of a society, especially that of the "establishment" within a society, affects science.

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	A. (cont.)	6. (cont.) Have students select contemporary cases that demonstrate how values may affect the direction, financing, or acceptance of scientific research. Examples: How might the following research proposals be affected by the values of some or most Americans? a. A program to find a cure for cancer. (Nixon's program) b. A plan to find ways to change genetic make-up of unborn babies. c. A project to develop ways to control population growth. d. Testing of a new germ-warfare technique. e. Oppenheimer Affair (See AEP pamphlet, Science and Public Policy.) f. Linus Pauling - Vitamin C, cold remedy response by public. (blind faith in Nobel prize winners) g. A device to test intelligence by measuring nerve impulses to the brain. 7. Discuss the effects of "science for national prestige." Students might gather information about the founding and growth of NASA and how it has affected the direction of government support for science in the U.S. Questions: a. Was President Kennedy's pledge to put a man on the moon a popular one? b. Was the decision made for scientific reasons? (Consider political, military, and economic factors.)

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	A. (cont.)	7. (cont.) c. Is there a conflict between the ideal of free international scientific communication and the modern competition among nations for scientific prestige? d. Have students compare the NASA budget with other science funds, e.g. NSF. Approximately 1/3 of the money aimed at basic research by the government was administered by NASA in the 1960's.) **Does this inhibit the "free" pursuit of basic research by restricting funds to achieving political goals in space?** **Were the benefits of the research sponsored by NASA restricted to progress toward space goals? (Have students find information on benefits of NASA research.)** 8. Discuss: Following Sputnik, the number of scientists and engineers in the U.S. graduating from college increased rapidly. Now this number is significantly decreasing. Why? Does this reflect a disillusionment with science? A lack of public support? Economic recession? What are students doing instead? 9. Discuss cases of public protest over scientific research; e.g. student protests at universities over military and secret research; protests against nuclear testing; against germ warfare experimentation.

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	A. (cont.)	10. Have a few students research the overall distribution of money for scientific research by the federal government during the current year. They might determine: a. How much money? b. From which agencies? c. Types of research supported? d. If possible, a comparison with research support of a few years earlier. The data collected may be illustrated via bar graphs on overhead transparencies, to be used as springboards for discussion of the relationship between public attitudes/values and scientific research. 11. If there are any students who have scientist parents or neighbors they might interview them to get their views on the dependence of science on public feelings. 12. Have a group of students prepare a debate, mock trial, or skit using the case Strunk v Strunk (see Appendix C) on the specific issue of the power of the court to permit a kidney to be removed from an incompetent ward of the state, and the general issue of the power and responsibility of government in applying medical and other scientific advances to society. Suggested discussion questions: a. Why was the kidney transplant needed? b. How did the court decide that the transplant might benefit Jerry? c. What moral problems are presented by this case? d. Do you think the court was right? e. What if such a transplant were needed but the organ were one that Jerry could not live without (e.g. heart)? f. What other problems can you predict that society will face as a result of the rapidly advancing medical technology of organ transplants?

GOAL 4: THE STUDENT WILL ANALYZE THE EXTENT TO WHICH SCIENTISTS SHOULD: A) CONCERN THEMSELVES WITH THE CONSEQUENCES OF THEIR WORK: B) BE ABLE TO INFLUENCE HOW THEIR WORK IS APPLIED BY SOCIETY.

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
SOCIAL RESPONSIBILITIES OF SCIENTISTS	A. Given past, present and hypothetical cases, the student will list ways that scientists can and/or should influence policy.	1. To introduce the students to the issues and persistent questions involved with this objective, use the A.E.P. pamphlet, Science and Public Policy, "A Fight over Flouridation." The crux of this case study is the complex problem of deciding whether certain issues should be settled by a majority of voters or the "experts," and what happens when there is conflict among the experts. 2. Use reprints of pertinent magazine and newspaper articles to obtain various points of view on the obligations of scientists to engage in social, economic, and political activities to influence how their work is applied. If possible, use selections from Synopsis, Vol. 1, No. 17, May 11, 1970, "Social Responsibilities of Scientists - New Proposals." (and the corresponding Teacher's Resource issue) Otherwise, students might locate appropriate articles, using the Reader's Guide or Science for Society: A Bibliography. (See Materials section.) Questions for research, reports, discussion: a. Should professional scientific organizations speak out publicly on issues involving science? Should they speak out on non-scientific issues (e.g. war in Vietnam)? b. Should scientists refuse to work on research they feel is immoral? Should those who decide to do such work be ostracized? c. Should scientists make decisions about how research may be used by society?

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	A. (cont.)	2. (cont.) d. Are scientists responsible for educating the public? e. Should scientists be more involved in political decision-making? f. What are the pros and cons of the question of social activism on the part of scientists? g. Discuss the concept of Scientific Elitism. 3. Invite a scientist or graduate student in science to discuss the social responsibility of scientists with the class. Or, ask him to submit to a taped interview with the teacher or students. A group of students could prepare 5-10 questions to ask the scientist. 4. Divide the class into small groups to investigate national issues which are science-related. Have each group examine the role scientists played or are playing in decision-making, protesting, or supporting various positions. Examples: a. The role of scientists in the decision to test a 5 megaton bomb under Amchitka Island. b. The role of scientists in the Congressional debate over support for a supersonic transport plane. c. The role of scientists in the decision to buy the Big Cypress watershed north of Everglades Park. d. The role of scientists in the decision concerning an Alaskan oil pipeline.

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	A. (cont.)	4. (cont.) e. The disagreement of government scientists and those who represent American tobacco manufacturers. If possible, issues selected should be of current interest. 5. Have an interested student report on the role of scientists in Nazi Germany, especially their positions regarding experiments using human beings. 6. Use local newspapers as sources of data for discussion of the proper role of scientists in public issues. 7. Have a committee make a bulletin board of current articles, entitled "Scientists Speak Out." 8. Have a committee collect cartoons that reflect science's role in public issues. Some students may be able to draw cartoons that reflect either the general dilemma or the scientist's role in society or specific current issues and scientists' activism. 9. Obtain from your Congressman or Senator the records of a recent public hearing related to science at which you know scientists testified. Have students read and discuss it: a. What positions did scientists take with regard to __X___ issue? b. What were the opposing viewpoints? c. Will the scientists have an influence on the outcome of the issue? Should they?

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	B. The student will demonstrate in a debate, discussion, essay or role-playing situation, knowledge of opposing viewpoints on the social responsibilities of scientists.	1. Topics for Debate: a. Scientists should offer their opinions and conclusions on issues but should not try to influence the ultimate decisions. b. Scientists should stick to science and let politicians decide how to apply scientific findings. c. Scientists should be named to all government posts and committees that relate to science and technology. 2. Have each student write an essay which includes arguments in favor of social activism by scientists, arguments against social activism by scientists, and his own conclusions about the role scientists should play in society. 3. Discuss: Is it possible to apply democratic processes, as we understand them, to decision-making in our technological world? (Must we turn over the decision-making processes to experts?) 4. Devise a role-playing situation where one (or more) scientist is trying to convince a colleague to take an active part on a public issue; his colleague will take the position that scientists must stay "above" politics and stick to only offering his provable conclusions.

GOAL 5: THE STUDENT WILL SPECULATE AS TO THE FUTURE ROLE OF SCIENCE AND TECHNOLOGY IN THE WORLD.

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
PREDICTIONS FOR THE FUTURE	A. The student will gather data from current "futurists."	1. Have students select portions of current books, such as Future Shock and The Biological Time Bomb to share with the class and discuss. (See materials section for additional titles.) 2. Refer to the Quinmester course, The Global Village in Century 21 for activities and resources related to science in the future. 3. Have students read "Tragedy of the Commons" by Garrett Hardin. (Printed in The Environmental Handbook, Ballantine Books, 1970.) If multiple copies cannot be obtained, it is recommended that the teacher use this though-provoking article as the basis for class discussion, reading excerpts aloud and inviting discussion. 4. Have students read and discuss the implications of technology and the future, as expressed by Richard D. Lamm. See Appendix B. 5. Show and discuss any of the following films: Automania 2000 (Rental) 1985 Machine: Master or Slave?
	B. The student will speculate on the future role of science in society.	1. Have each student write an essay titled, "The Impact of Science on Society during my Lifetime." If some students are science-oriented, they may wish to write the essay within a more limited scope, e.g. biology, chemistry, etc.

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	B. (cont.)	2. Have groups of students examine the following problems and report to the class on: a. The feasibility of this occurring by the year 2000. b. The consequences for society. c. The role of the scientist in applying it. d. The advantages and disadvantages - predictions. Control of aging: extension of life span indefinitely Artificial placentas and true baby-factories Improvement of intelligence in man and animals through drugs Artificial viruses Power to modify heredity 3. Present students with situations which presumably could develop in the future or have students create such situations for discussion. An example: Women may go into the supermarket in the future and shop around for day-old frozen embryos. On the package will be a glamorized 4-color 3-D picture of the adult expected on the pack, as when one buys a package of seeds. What is to prevent firms from marketing such products? Should such packages be available to all? to those who get a doctor's prescription? Can society cope with such an advance in science? What responsibilities do scientists have, if any, in managing research aimed at packaged embryos?

FOCUS	OBJECTIVE	LEARNING ACTIVITIES
	B. (cont.)	4. For thought and discussion: a. Can society resolve the ethical and moral problems that accompany scientific advances fast enough? b. Is the relation between science and society today a race between education and catastrophe? c. Have science and technology given us more options or fewer options in our life styles? d. Will our complex law-making and legal systems be able to keep up with the rapid scientific changes occurring in our society?

APPENDIX A

"In Goya's greatest scenes...."

Poem
Lawrence Ferlinghetti
From A Coney Island of the Mind.

In Goya's greatest scenes we seem to see
the people of the world
exactly at the moment when
they first attained the title of
"suffering humanity"
They writhe upon the page
in a veritable rage
of adversity
Heaped up
groaning with babies and bayonets
under cement skies
in an abstract landscape of blasted trees
bent statues bats wings and beaks
slippery gibbets
cadavers and carnivorous cocks
and all the final hollering monsters
of the
'imagination of disaster'
they are so bloody real
it is as if they really still existed

And they do

Only the landscape is changed

They still are ranged along the roads
plagued by legionaires
false windmills and demented roosters

They are the same people
only further from home
on freeways fifty lanes wide
on a concrete continent
spaced with bland billboards
illustrating imbecile illusions of happiness

The scene shows fewer tumbrils
but more maimed citizens
in painted cars
and they have strange license plates
and engines
that devour America

APPENDIX B

TECHNOLOGY ASSESSMENT AND THE BRAVE NEW WORLD OF THE FUTURE

By: State Representative Richard D. Lamm

"Technology" is one of the most important words in the twentieth century vocabulary. It promises to bring a cornucopia of benefits to mankind, and simultaneously solve by more of the same any problems caused by the production of those benefits. It is the twentieth century equivalent of the miracle of the loaves and fishes.

Scientists, technicians and the public at large react defensively to any criticism or questioning of technology. The profound cliche goes "Technology is not bad itself; it's what we do with it." Any interference with "seeking for truth" is unthinkable, any problem "caused by science will be solved by science."

It is not quite that simple. Mercury pollution, radiation, detergents, insecticides, asbestos, air and water pollution -- all have recently shown there is another not-so-pleasant side to technology. We are finding that there are many subtle but potentially far-reaching toxic insults which we are releasing into our atmosphere, adding to our foods, spreading on our farmlands, produced directly or indirectly by our industries. We are sweeping at an accelerating pace into an unknown future sustained by a new blind faith in science and the thin straw of hope that we will be as successful in the future as we have been in the past.

There is another facet to the complexity. Recent advances in biology, genetics, and medicine show us that biomedical technology might hold the biggest surprises of a surprise-filled future. The next twenty years may well see the laboratory fertilization of humans, pre-determination of the sex of unborn children, control of aging, development of an artifical placenta, asexual reproduction of human beings (cloning), the production of animal-human hybrids (chimera), genetic surgery, drugs to modify behavior. The list of immediately recognizable "advances" is awesome; the possible unknown or unrecognized "breakthroughs" give reason for pause. Recently, Leon R. Kass, a noted biochemist stated, "We need only consult Aldous Huxley's prophetic novel Brave New World to get an indication

of where we are likely to be going. In Huxley we encounter a society dedicated to homogeneity and stability, administered by means of instant gratification, and peopled by creatures of human shape but of stunted humanity. They consume, fornicate, take 'soma', and operate the machinery that makes it all possible. They do not read, write, think, love, or govern themselves. Creativity and curiosity, reason and passion, exist only in a rudimentary and mutilated form. In short, they are not men at all."[1.]

There are yet other facets. Technology may usurp much of our privacy, making Brave New World a reality and bring George Orwell's 1984 a reality before its time. Microminiaturization has reduced the size of microphones—to the size of a matchhead carrying conversations more than a quarter of a mile, and one scientist promises a mechanism for recording speech through solid walls via a reflector made of a thin diaphragm and a microwave antenna. More yet -- we can already photograph from afar, tap telephone lines, spy via closed circuit T.V., and determine the content of mail without opening it; behavior modifying drugs have already been used to "pacify" [illegible]. We may soon be able to do more than invade privacy; we may soon be able to control actions. [2.]

We thus are finding increasingly that technology is a two-edged sword; we are finding that much more thought must be given to its impact on society. We are finding that the old mechanisms are not adequate to control the new dangers. This is due to four main reasons.

The first results from the mere speed of technological change itself. The rate of change is accelerating rapidly. We spend today some 16% of our total federal budget on Research and Development, and private industry injects vast billions more into the process of technological change. The former slow, careful process of invention, application and dispersement of new technologies has been condensed in time. We experience a millenium of change every few years. [3.]

The second involves our ability to effect change in greater numbers of people. When we made a pollution mistake in 1930, only a few downstream users were affected. If we make a mistake in 1970 with the underground nuclear detonations in the Western United States, we poison the whole Colorado River system. Concentrations of persistant pesticides, especially D.D.T., are causing subtle but real ecological damage, the extent of which is unknown. But with more than 1.5 million tons of D.D.T. now cycling throughout the biosphere and much of it still chemically active, it seems terribly ex post facto to begin now to weigh the odds of serious harm. The magnitude of possible harm should affect the equation -- even small odds look large in view of the stakes.

Third is that our control mechanisms require "proof" of the harm "No one has proved cigarettes are harmful to health," says the American Tobacco Institute; "No one has proved D.D.T. is carcinogenic" relates Monsanto Chemical defensively; "No one can prove that the radioactivity will find its way into the Colorado River system" says the A.E.C. All of these statements may, admittedly, be true. Yet this much is known: that many respectable scientists say to the contrary, and if they are correct, by the time they are able to prove their case it will be too late to avoid large-scale social harm. New mechanisms other than "proof" are required.

Last, the market system as a traditional control of technology is no longer adequate to guide rapid technological development. Massive federal funding into atomic energy, into supersonic transports, into Research and Development generally supplants the public demand of the market system as a decision mechanism. Washington bureaucrats set priority of needs, and without adequate management or control, funnel federal funds into certain projects while ignoring others. Traditional regulatory agencies, for a number of reasons, cannot or do not adequately protect the public interest.

THE NEED FOR NEW MECHANISMS

The future is not going to give us time leisurely or even adequately to debate all the legal, social, and political implications of technological change. Observing the emotional and polarized debate on the relatively modest abortion law change of three years ago, one cannot help wondering at the recent meeting of the American Association for the Advancement of Science that we close additional sub-humans to serve as spare-part banks for organ transplants. We may be closer to such decisions than we now realize. A recent Kentucky Court of Appeals decision authorized the removal of a kidney from an institutionalized demented man to transplant into his mentally productive brother.[9] The implications of these and similar future decisions are obvious, and the dialogue should begin now rather than waiting for the hysterical reaction after the fact.

It does not dampen our national commitment to technological advance if we insist upon the development of better systems to monitor technology, to build a system of checks and balances to insure that every possible and identifiable consequence of technology is taken into account.

The most important single improvement would be the development of mechanisms to weigh adequately both the costs and benefits of technology including both the odds and stakes of error. This in itself needs further breakdown.

We must first reverse the present system where those who sponsor technology self-servingly put great emphasis on short-term benefits and little weight on long-term costs. The National Academy of Sciences recently concluded that a "constellation of organizations" is necessary to insure a realistic balancing of costs and benefits.[5] One such organization was suggested by Congressman Daddario who sought to create an Office of Technology Assessment within Congress which will advise the members of Congress on the implications of various technological decisions they are called upon to make. The bill aims at providing Congress a means "for securing competent, unbiased information concerning the effects, physical, economic, social and political, of the application of technology..." [7].

A second improvement would involve a better equation which includes "uncertainty" in the decision process. "We simply do not know all of the results of our actions. As one scientist notes, " we are now well embarked on a program of releasing unmeasured quantities of different kinds of biologically active substances into the general environment. It is one of the spectacular contradictions of our time that in the Age of Science we should be entering blindly on a thousand, unplanned, uncontrolled, unmonitored, unguided, largely unrestrained, and totally unscientific experiments with the whole world as the subject and survival at hazard." [8]. Another commentor stated, "A hundred years ago Claude Bernard, the famous French physiologist, enjoined his colleagues, 'True science teaches us to doubt and in ignorance to refrain.' What he meant was that the Scientist must proceed from one tested foothole to the next (like going through a mine field with a mine detector). Today we are using the biosphere, the living space, as an experimental laboratory." [9].

A third improvement would be to produce better tools to protect society from those who seek to exploit technology. Private industry can still hide behind "lack of proof" and all too often prevent governmental and private action. To control pollutors, we need stronger and more effective laws which take into account possibility of harm and not merely "proof." We can no longer wait until we have detailed scientific proof of damage before allowing a plaintiff in court or catching a politician's attention.

Professor Michael S. Baram, a lawyer-scientist at the Massachusetts Institute of Technology in his paper The Social Control of Science and Technology discusses the inadequacy of the present legal system:

> "This characteristic of retroactivity limits the ability of the legal system to respond to a number of modern social problems, in particular the harmful effects of science and technology, and environmental deterioration. Retroactivity is inherent in a legal system based on the values and conflict of the private sector of society. The courts have not been designed to serve as oracles, but to grapple with actual conflict manifested in specific acts or injuries. They lack the technical astrological or other expertise needed for the difficult task of evaluating diffuse effects and future effects. Consequently, the courts are reluctant to impose control and, for example, have rarely intruded on the substantial decisions of public agencies.[10]

One example of the need for new mechanisms is the Project Plowshare Program of the Atomic Energy Commission. Long-range Plowshare plans include the possibility of hundreds of nuclear underground detonations in Western United States aimed at developing natural gas and oil shale, building new Panama Canals, harbor excavations and other twentieth century miracles. Increasingly, scientists both within and out of the A.E. C. are criticizing the agency's manner of decision-making which (it is charged) overestimates the benefits of nuclear energy and minimizes the risks. The same agency which is given the duty to promote the "peaceful uses of the atom" is also given the duty of protecting the public from the dangers of radiation; these two duties may well be inconsistent.

The Atomic Energy Commission then, like private industry promoters of technology, tend to stress short-term benefits and to minimize long-term costs. They do not take "uncertainty" adequately into consideration because by definition it is not "proved." A panel on Technology Assessment set up by the National Academy of Sciences found this to be a usual pattern of promoters of technology: "Historically the burden has tended to fall on those who challenge the wisdom of a technological trend. The usual presumption has been that a trend ought to be allowed to continue as long as it can be expected to yield a profit for those who are exploiting it, and that any

harmful consequences that might ensue either will be manageable or will not be serious enough to warrant a decision to interfere with the technology." 11.

If the Atomic Energy Commission's Plowshare program on nuclear stimulation of natural gas is "likely" to eventually release radioactive isotopes into the Colorado River system, as some experts claim, the mere possibility of poisoning a large and vital river system should make us pause; the odds seem less important when the stakes loom this large.

The Plowshare Program is merely one example of many possible technological backlashes. Respected scientists are on both sides of many applications of technology: pesticides, detergent and enzyme pollution, supersonic transports, nuclear reactors, weather modification and radioactive isotope disposal. One could list endless scientific advances.

What wisdom can society bring to these problems? One improvement would be an awareness of science's own limitations. "Science at best is not wisdom; it is knowledge, while wisdom is knowledge tempered with judgement." 12. This judgment is too often missing in the accelerating pace of scientific advance. Lewis Mumford, writing in The Automation of Knowledge, states it succinctly:

> "... decisions of critical importance to the human race are being taken today on the basis of ten year old knowledge, confidently applied by highly disciplined specialists who too often display the short comings of ten year old minds, for they regard as a special merit their deliberate practice of cutting their minds off from ten thousand years of human experience and culture. ...strangely, they have not even a suspicion that the vast quantity of exact knowledge now at our disposal is no guarantee whatever of our having sufficient emotional — sensitiveness and moral insight to make good use of it: if anything, the contrary has already proved true."

Inherent in that judgment is an incredible array of different and sometimes competing considerations. Foremost among these is, of course, national priorities. Much has been written of the need to

distinguish between the "ability" and the "wisdom" of going to the moon. Both the political process and the public imagination are easily seduced by flashy scientific exploits which have little relevance in finding less glamorous but more important solutions to the problems of a troubled society. Hopefully, the defeat of the S.S.T. is a harbinger of an increased public awareness of national priorities.

Equally important but less appreciated is the tendency of science to sacrifice humanism for knowledge. Catherine Roberts, a biologist herself, in her book The Scientific Conscience states that biology stands today where nuclear physics was in the early 1940's, intoxicated by the precipitate advance of scientific knowledge, but without a full realization of the moral commitment. Criticizing biologists for attempting to go far beyond understanding life process, she states that "...do not stop with understanding life, much less respecting it: now with unlimited optimism and with apparent lack of recognition of the possible consequences, it desires to alter life."

She suggests that our age must better distinguish between the qualitative and quantitative aspects of man's existence, and that it is far less important to extend our intellectual frontiers than it is to become more human. She states:

> "For scientific progress today is an intellectual obsession that threatens to become uncontrollable unless scientists themselves exercise some self restraint in its pursuit. Unchecked, it will lead straight to a scientifically directed world in which the intellect so dominates the spirit that man will no longer be interested in becoming more human."

The new mechanisms of weighing the costs and benefits of technology must then include the possibility of a judgment that certain areas of scientific advance are certain to be counter productive. Increasingly, scientists themselves are suggesting that science and technology puts us in a position to do things we should never do. Dr. Hass suggests that the moral and ethical problems in human cloning (which produces a human genetically identical to the adult donor and could yield large numbers of identical individuals) are such that we should never produce one such individual.

even as an experiment.[13.] Those who would not draw the line here need only imagine the production of animal-human chimeras to recognize the vast ethical, moral and social questions involved. Do we not want, at least in a few limited areas, to say to science -- "Let us not go in that direction."?

Technology, then, may well be "neutral" but mankind cannot afford to be neutral about technology. We must start to consider the profound questions inherent in a fast-moving technology. We must institute safeguards to insure that technology serves but does not control or destroy man. The Swedish Ambassador, in announcing the International Conference of the Environment to be held in Stockholm in 1972, stated: "Even if we avoid the risk of blowing up the planet, we may, by changing its face, unwittingly be parties to a process with the same fatal outcome. Indiscriminate and uncontrolled use of modern technology, indispensable as such technology is for economic and social progress, may set trends in motion which lead to unforeseen harmful defects in unprotected niches." [14.]

We are accelerating at increasing speed into an unknown and potentially dangerous future. We must thus accelerate the dialogue on how society can separate the dangers of technology from its benefits, and expand that dialogue on the moral, ethical, and social implications of certain aspects of that technology. We must insist that technology <u>serve</u> man -- not destroy him either physically or spiritually.

FOOTNOTES

1. "Beware the Brave New World", a paper delivered by Dr. Leon R. Kass at the Center for Democratic Studies, Santa Barbara.

2. "Technology and Human Rights", VISTA, November-December 1970.

3. Green, Harold P. "The New Technological Era: A View From the Law." Program of Policy Studies in Science and Technology, The George Washington University, Washington, D. C., Monograph No. 1, Nov. 1967. Dr. Green's material on the relationship of the law to technology is a brilliant survey and should be read carefully by everyone interested in the subject.

4. Green, Harold P., supra. See also Green, Harold P., "The Adversary Process in Technology Assessment" speech presented at the Technology Assessment Seminar Series Program of Policy Studies in Science and Technology, The George Washington University. March 19, 1969.

5. Strunk v. Strunk, Court of Appeals of Kentucky. Rendered September 26, 1969.

6. Brooks, Harvey and Bowers, Raymond, "The Assessment of Technology." Scientific American Volume 222, No. 2, February 1970. p. 13.

7. See generally Hearings on H.R. 17046 before the Subcommittee on Science, Research and Development of the Committee on Science and Astronautics U.S. House of Representatives, Ninety-First Congress Second Session. Parts I and II. May 20, 21, 26, 27, June 2 and 3, 1970.

8. Woodwell, George M. "Radioactivity and Fallout: The Model Pollution." Bioscience, Vol. 19, Nov. 19, 1969. pp. 884.

9. Lord Ritchie-Calder, "Mortgaging the Old Homestead", Foreign Affairs, January 1970, p. 208.

10. Baram, Michael S. "The Social Control of Science and Technology", given at the University of Denver, College of Law Conference on "Implications of Science and Technology for the Law." November 6, 1970.

FOOTNOTES (cont.)

11. See Footnote 6.

12. Lord Ritchie-Calder "Mortgaging the Old Homestead", Foreign Affairs, January, 1970, p. 208.

13. Supra, Footnote 1.

14. Kelly, Frank K. "The Possibilities of Transformation". Saturday Review, March 7, 1970.

Appendix C, consisting of a case study of a Kentucky Court of Appeals, was removed from this section, as it was not reproducable.